

Technical Memorandum

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SPECIAL PROJECTS FLATS

The optical system for Special Projects was tested as a completely assembled unit during December. Certain characteristics of its performance indicated that some of the scanning flats were responsible for unacceptable amounts of degradation. After disassembly of the unit, the flats were tested by a scatter plate technique illustrated in Figure 1.

Each flat, still mounted as it is to be used, was brought into a position so that the optical path from the scatter plate to the flat was reflected vertically downward to a spherical mirror. Thus, the scatter plate was positioned at the center of curvature of the sphere as reflected by the flat, and the flat was thus positioned at a 45° angle to the vertical corresponding roughly to its normal position in use. The scatter plate was adjusted in focus to give as nearly a straight central fringe as could be obtained. The adjustment, in lateral position, was made to provide 6 to 8 fringes across the aperture. A mercury lamp provided a source of light and the fringes were photographed by a camera equipped with a Steinheil Quinar f/2.8 135mm lens. A yellow filter was placed in front of the camera lens. Contours of the surface of each flat were obtained by the steps illustrated in Figure 2.

An enlargement of the negative was made to provide a picture of the fringes approximately 5x7" in size. By eye, small holes were pick-punched through the center of each bright fringe, spaced random along the fringe, close enough together to indicate the regions of strong curvature. The print was then overlaid with a piece of drafting paper on a light table and the small holes were clearly visible. Three points are selected through which to pass the reference plane; two of these must be along the same fringe and the third should be separated by 4 or 5 fringes. The selection of these points will determine the shape of the contours finally plotted, but with some skill this method provides a reference plane very close to the optimum.

A straight line is drawn between the two points selected on the same fringe and the perpendicular distance from this line to the third point divided into the same number of equal spaces as there are fringes between the line and the point. Lines parallel to the reference line are then drawn through these points and additional points with the same space external to the line and the selected point. Since the flat is at 45° and is seen in reflection twice, the space between two fringes represents $\frac{1}{2}\lambda$ displacement of the surface. A small ruler is made up divided in such a way that the spacing of the reference lines represents .354 λ . The distance of each

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point pricked in the print from its corresponding straight line is measured with this scale and that number recorded next to the point. The contour lines are then drawn by eye through the grid of numbers. Figure 3 shows the contours of the four flats on the forward scanner.

It can be seen that flats 1, 2 and 4 are rather strongly astigmatic, while #3 is saddle shaped. Number 4 is by far the worst, having some $.6\lambda$ from its lowest to its highest point and no juggling of the reference surface can make a significant improvement in this value. Figure 3 is the best, having a maximum deviation of only $.25\lambda$, and it is felt that the subtraction of some spherical power, which might actually be power in the flat or a small error in focal position of the scatter plate, would greatly improve the appearance of these fringes.

Flats # 1 and 2, having ranges of $.3\lambda$ and $.4\lambda$, are primarily simple cylinders. It is interesting to note that of these surfaces, only flat #3 gave images approaching acceptable resolution.

Figure 4 shows similar contour plots for the four flats on the aft scanner. Flat #2 appears to be much the best of the lot so far. Although the maximum range of departure is still $.2\lambda$, the majority of the surface area is well within $.1\lambda$. Flat #1 is strongly astigmatic. Flat #3 is almost pure saddle with a range of $.4\lambda$. The axes of the saddle appear to go through the corners on flat #3 and through the centers of the side on flat #4. Number 4 has an extreme range of $.4\lambda$. So far then, we have two flats, #3 from the forward scanner and #2 on the aft scanner, which might be good enough to use on the next assembly.

Figure 5 shows flat #4 after it was removed from its mounting and, by comparison of the before and after fringes, it is seen that the shape of the surface has not been significantly changed. A slightly different set of fringes led to a different choice of reference plane, but the over-all shape of the surface remains unchanged. Flats R1, R2 and R3, also shown in Figure 5, are the so-called "reworked" flats. Of these, R2 is much the best and begins to approximate the quality which we require. R1 and R3, both with approximately $.2\lambda$ peak to peak deviation, are of the same general quality as flat #3 and flat A2, and so we should probably use those on the next assembly as well. It is hoped that the technique which produced these reworked flats can be further improved to produce results like R2.

Figure 6 shows two folding flats, neither of which have been used in existing systems, and the folding flats in the camera are not available for this test. Of these two, #9 is the better, although it would appear that both could be used. It is to be remembered that two-inches is still to be cut from the bottom of these flats and that, if this were done, a better reference plane could be chosen. It would appear that both would then be within $.1\lambda$ peak to peak.

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Before closing, the following comments about the method are in order. It is felt that this method is simple and straightforward and the reduction is a routine matter, taking approximately one-half hour per set of contours. On the other hand, the method probably does not provide an accuracy of better than $1/20\lambda$ as it now is employed. Locating the proper focus by eye is perhaps not sufficient for accuracies better than this value and it is not possible with this method to separate with certainty the spherical errors and astigmatic errors in the flat under test. I do not believe that one would be misled by the fact that a good flat would appear bad, but there is some danger that an error interpreted as astigmatism might well be spherical and of the same magnitude. In our present use, these two types of errors are equally destructive of image quality. In the future, we would intend to use Fabry-Perot type interference for the checking of the quality of these elements.

It is the conclusion of this investigation that the folding flat presently in use in the forward camera should be retained since this complete assembly has given good images. Folding flat #9 should be cut and coated and used for the aft camera. The forward scanner should be provided with flat #3, presently on it, and reworks R1, R2 and R3. These should provide a nearly acceptable forward scanner. Unfortunately, the aft scanner must remain the way it is, with only A2 expected to produce good images. It is possible that new flats will be available late in March, but we should proceed with the assumption that they will not.

RMS/sa

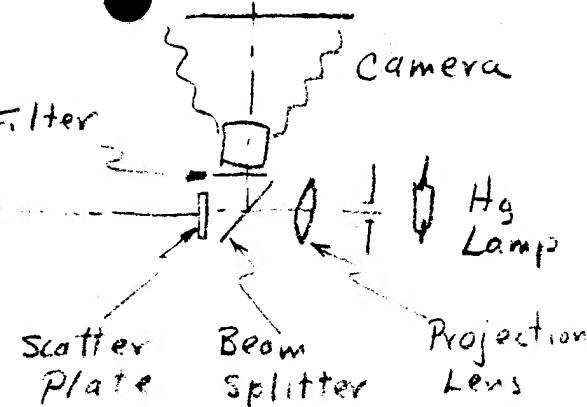
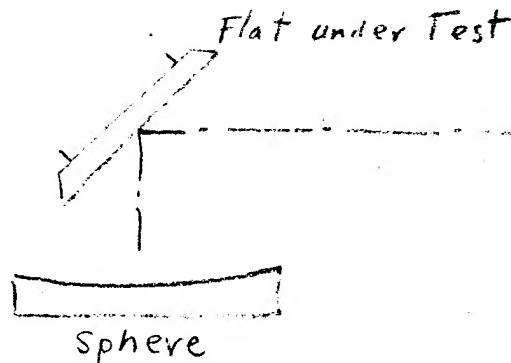
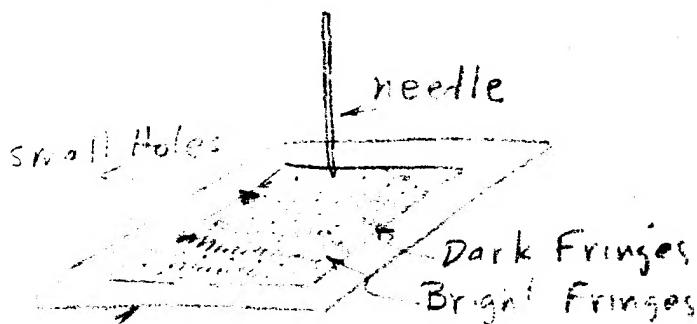
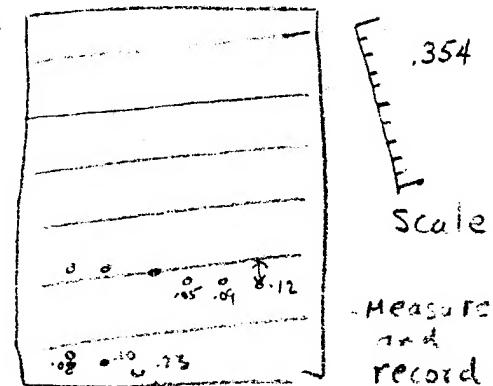
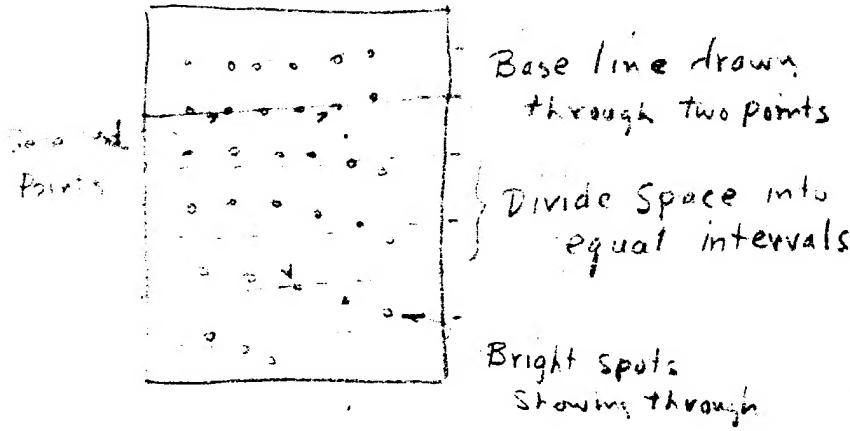
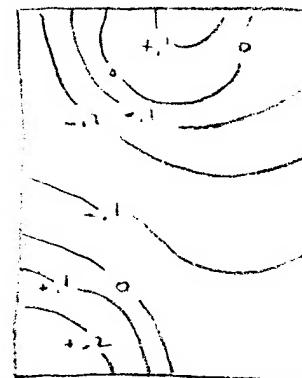


Fig 1

Print of Step 1

Step 3

Print, and Paper overlay on light Table Step 2

Draw Contours

Step 4

Fig 2

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